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A
Treatise
ON
PERSPECTIVE,
IN WHICH THE WHOLE OF THAT ART IS REDUCED TO ONE GENERAL RULE;

WITH

DIRECTIONS FOR DRAWING FROM MODELS.

ALSO,

A RULE FOR CALCULATING THE APPARENT SIZE OF AN OBJECT;

A DESCRIPTION OF AN UNIVERSAL RULER;

AND A MODE OF MAKING PERSPECTIVE DRAWINGS BY THE RULER AND CALCULATIONS.

By SAMUEL B. HOWLETT,

MILITARY SURVEYOR AND DRAFTSMAN.

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Finding it necessary, about twenty years ago, to acquire a knowledge of Perspective, the Author studied several works upon the subject, but not being able to select from them any rules available for his purposes, he tried various experiments, from which he deduced a rule which has proved sufficient to meet every case which has occurred in his practice. As the rule is convenient, correct, and general in its nature, it will probably be acceptable to many persons who wish to study the subject, but who are not disposed to perplex themselves with volumes which contain an endless number of different rules and diagrams.

It may be proper to remark, that the whole of this work may be proved to be correct by comparing it with two established truths in geometry, namely, that "the sides about the equal angles of equiangular triangles are proportional," and that "if a pyramid be cut by a plane parallel to its base, the section will be to the base as the squares of their distances from the vertex."

Under the above considerations, and with every feeling of diffidence, the Author ventures to offer his Treatise to the Public.

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A

TREATISE ON PERSPECTIVE.

INTRODUCTION.

A WRITER in a respectable Encyclopædia, after having given a complicated diagram to explain his method of putting a square into perspective, remarks, that "the variety of constructions of this problem is very great, and it would fill a volume to give them all."

Writers on perspective do not appear to think it practicable to give a general rule by which all objects whatever may be put into perfect perspective; but, on the contrary, they give perhaps a hundred examples of different objects in perspective, and make up a large volume with explaining the hundred different ways and contrivances by which those examples were constructed.

Many persons possessing a tolerable knowledge of geometry, who have devoted much time and attention to the study of some of these works, have found that all the information they were able to obtain from them, amounted to little more than a vague notion about a point of sight and a point of distance, to be placed somewhere in the horizon, and to which points the various parts of a building or other object must respectively be made to vanish; and that though much was said about vanishing points, yet that no intelligible rules were given by which those points were to be found. With this imperfect information they have made perspective drawings, and though something like an approximation to the truth was produced, yet it was done more by the eye than by rule.

Considering how intricate and difficult the art of perspective is rendered to a learner, in consequence of the multitude of unintelligible rules and examples which are offered to his attention, and that even some of the best and most popular of those rules are not of universal application, it would of course be rendering an important benefit to the learner, if he could be enabled, by a few hours' study, to acquire a clear and correct knowledge of the fundamental principles of perspective, regarding it as a branch of science, and be put into possession of a general rule, founded upon those principles, that would serve him for all possible cases, and the truth of which could bear the test of the most severe experiments to which it could be subjected.

The design of this treatise is to endeavour to explain the fundamental principles of perspective in such a way as that the pupil may be able to acquire a thorough knowledge of the science; and to submit one general rule, deduced from actual experiments, by which all objects whatever may be drawn in perfect perspective.

There are many persons who would be glad to acquire a knowledge of perspective, but are deterred from studying it, in consequence of the endless number of problems and diagrams with which the subject is usually perplexed. But if it were known that a perfect knowledge of this art could be gained by studying only one simple rule, there could be no doubt that perspective would be more generally used in different branches of the arts than it now is.

The chief excellency of this rule is, that it has the power of finding the true situation of any one given point of an object, as it would appear in perspective, without the aid of vanishing points. It is therefore particularly applicable to the drawing of machinery, and other irregular objects, which, by means of this rule, may be so represented on paper as to convey an idea of the object almost as correctly as it could be given by a model itself.

This rule would be of great use in making drawings of projects for military works, and it is perhaps the only rule that is available for such a purpose. If the usual plans, sections, and elevations of fortifications, were accompanied by a good perspective drawing, showing the project as it would appear to an eye looking down upon it from a great height, it would answer the purpose of a model, and would serve to connect and explain all the other drawings, which, however well constructed, are nevertheless difficult in most cases to understand. To make a drawing of this description would be a tedious task, but even if it should require two or three weeks of close application to execute it properly, that additional labour cannot, it is presumed, be regarded as a question of the least importance, when it is considered that the amount of the estimate for that work is perhaps two or three hundred thousand pounds, and also that the fortress itself is possibly of so great political importance as that the very existence of a State depends upon the skill with which it is constructed. When an architect submits his design for a building, the plans are generally accompanied by a perspective view, showing the effect they will produce when executed; and certainly when projects for works of fortification are submitted, the utmost powers of art should be employed in endeavouring to convey the most perfect idea of those projects to the high Authorities who have to judge and to decide respecting them.

Considering that it has been thought necessary by most authors to give so many problems and diagrams, and to write so voluminously, in order to teach the art of making perspective drawings, it would certainly be esteemed an essential service rendered to the pupil, if the whole subject were reduced to one rule, even though that rule were difficult to learn, and though it might not be, in some particular cases, so convenient to use as other rules which might be contrived. In going through the explanation of the General Rule now about to be given, the pupil will bear in mind, that while he is learning the rule he is at the same time learning the science of perspective, and that rather a difficult problem is selected for him to work upon, because it is one which is best calculated to exemplify the general nature of the rule in question. But when once he has made himself master of the principles of perspective, with the way of applying them to practical purposes, as taught in the following pages, he will find the rule both simple in itself and convenient in practice.

GENERAL RULE BY WHICH OBJECTS OF EVERY DESCRIPTION MAY BE DRAWN IN PERFECT PERSPECTIVE.

WRITERS on Perspective agree in stating, that if we view an object, a building for instance, through a sight, or small hole, to steady the eye, and trace the outline of the building as it appears upon a pane of glass placed between the eye and the object, that that outline will be a true representation of the object; and that therefore the art of perspective consists in enabling a person to draw by rule a similar outline to that which he traced upon the glass—of course supposing that he is furnished with the necessary data, such as the dimensions of the building, the spot from which he is to view it, and the height of his eye from the ground.

Let the irregular pentagon ABCDE, figure 1, represent the roof of a shed, supported at the angles by pillars each ten feet high, with its highest point at F, sixteen feet from the ground. It is required to put this building into perspective, supposing the observer to be at O, and to view it at the height of five feet from the level of the ground, upon which the building stands, looking in the direction of the line OS.*

At right angles with the line OS, being the line of direction in which the building is to be viewed, draw the line GG, to represent the bottom edge of the plane upon which the drawing is to be made, and at such a distance from the point O as may be most suitable to the size of the intended drawing.

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* The line of direction should always be towards the centre of the drawing.

The learner will make his drawing on paper, but in order to assist the mind in comprehending the subject, we will suppose the plane on which the drawing is to be made, to be a square of glass. Let the square GHHG, figure 2, represent a pane of glass, and let it be understood that the line GG, figure 1, represents the bottom edge of that pane, and that the line GH, figure 3, represents the vertical section of the same pane, on either of the lines, *bb*, *cc*, *dd*, *ff*, *aa*, *ee*, figure 2.

From an inspection of the figure 1, it is manifest that rays of light passing from the pillars of the building to an eye at O, would respectively pass through a pane of glass, placed upright at GG, at the points *b*, *c*, *d*, *f*, *a*, *e*, as shown by the dotted lines.

The learner will draw across the sheet of paper upon which his drawing is to be made, the ground line GG, figure 2, at any height on the paper he finds convenient; but as we are supposing the drawing to be made on glass, let the bottom edge of the pane, marked GG, represent the ground line. To this ground line transfer the points *b*, *c*, *d*, *f*, *a*, *e*, from the line GG, figure 1, and upon each of these points erect the perpendicular lines *bb*, *cc*, *dd*, *ff*, *aa*, *ee*, figure 2. Now supposing the pane of glass to be held up upon the line GG, figure 1, so that the letters correspond to each other, it is evident that the pillar A, for instance, will be seen by the observer somewhere in the line *aa*, figure 2, and that nothing remains to be done but to find the two points (*x* and *z*) in that line through which the top and bottom of that pillar will be seen, in order to draw it in the picture in its true apparent size and situation. Of course the same remark applies to all the other pillars and parts of the building.

On a separate paper draw the ground line, figure 3, and parallel to it, at the height of the observer's eye, namely five feet, draw the line of the horizon.* From a convenient part of the ground line, erect the perpendicular line GH, to represent the vertical section of the pane of glass GHHG, figure 2, on either of the lines *bb*, *cc*, *dd*, *ff*, *aa*, *ee*; or on either of the corresponding points, *b*, *c*, *d*, *f*, *a*, *e*, in the line GG, figure 1, which has been explained before.

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* Set off all the distances from a scale.

point a, figure 3, must pass through the intervening pane of glass, GH, at the point x, and in like manner a ray of light from the bottom of the same pillar to the observer's eye, would pass through the glass at z; therefore the height Gz is the height that the bottom of the pillar A would appear to be from the ground line or bottom edge of the glass, and the point x marks the apparent height of the top of that pillar.—But to ascertain these two points (x and z) was all that was wanted in order to complete the representation of pillar A in the line aa, figure 2.

Set off the distances Gz and Gx, figure 3, upon the line aa, from the point a, in the ground line GG, figure 2, and then

---

right of the point a, figure 3, and the point b is ascertained, which will be the place of the observer's eye for pillar B.

will the apparent size and situation of pillar A upon the pane of glass GHHG be correctly determined, because it has been already agreed that the pillar must be seen somewhere in the line *aa*, and it has just been shown that the top and bottom points of it must be seen through the points *x* and *z*.

Having fully explained the process by which the apparent size and situation of pillar A was determined, it is only necessary to remark, that the same process must be gone through in order to ascertain the apparent size and situation of the remaining four pillars, and to get the height of the top point of the roof. When this process is gone through, draw lines from the top of the roof F, figure 2, to the tops of the pillars, to show the ridges of the roof; and draw a line from the top of one pillar to the top of the next pillar, and so on all round, to show the eaves of the roof; also, to make the drawing more complete, draw a line from the bottom of one pillar to the bottom of the next, and so on all round. All this being done, we shall have a perfect representation of the irregular pentagonal building in perspective upon the pane of glass GHHG, figure 2, according to the given data, as was required.*

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* The whole of the General Rule has now been explained; and from what has been said it is presumed that the ingenious pupil has been able to gain tolerably clear conceptions of the theory and practice of perspective; but in order to remove any difficulties he may have on the subject, a perspective drawing, figure 4, is given, in which may be traced the first three figures. On the top of the table, the ground plan, or figure 1, may be seen, with the pentagonal structure erected on it; and the upright pane of glass will explain what has been said relative to figure 2.

As the process in figure 3 is the most difficult of the whole to comprehend, the pupil is advised to compare it attentively with figure 4. To have

It is proper to remark here, that if the line drawn from the top of pillar A to the top of pillar B, and the line drawn from the bottom of pillar A to the bottom of pillar B, figure 2, be both very carefully produced, they will intersect each other in one point in the horizon, called a vanishing point. Now suppose the building to be enclosed, and that there are doors or windows in the side between the pillars A and B, the horizontal lines of

drawn lines from the eye-hole in the sight to the several parts of the building to represent the rays of light, as they pass through the intervening pane of glass, would have rendered the figure too confused; but if a ruler be laid from the top or bottom of any one of the pillars to the eye-hole, it will be found to cut the corresponding point in the glass. However, by way of example, lines are drawn from the top and bottom of pillar A to the sight, to show how they cut the glass in the section line *aa*, in the points *x* and *z*, by comparing which with figure 3, the pupil will surely be enabled to understand what has been said relative to GH, in figure 3, being supposed to be a section of the glass on either of the lines, *aa*, *ff*, &c. in figure 2.

those doors or windows will all appear to vanish towards the same vanishing point in the horizon. The same remark applies equally to all the other sides of the building, that is, each side will have its vanishing point in the horizon. In some cases it is not necessary to find these points; but in other cases they are indispensibly necessary (unless the pupil provide himself with an Universal Ruler, as described in Appendix No. 2,) especially in drawing the views of regular buildings.*

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* Though the rule which has been explained, will be found sufficient for all possible cases, yet there is a beautiful rule for putting buildings into perspective, in use among architects, which it is desirable for the pupil to know.

Let ABC, figure 5, be the plan of a building, to be viewed by an eye at O, looking in the direction of the line OBS.

At right angles with the line OBS, and through the point B, draw the line DE, to represent the plane of the picture, and draw the lines OA and OC. Parallel to the sides of the building, draw

The learner has now before him all that is necessary for him to study in order to

the lines OD and OE, cutting the line DE in the points D and E.

Draw the ground line, figure 6, and parallel to it, at the height of the eye from the ground, draw the horizon line. From the line DE, figure 5, transfer the points D, *a*, B, *c*, and E, to the horizon line, figure 6. Through the points *a*, B, and *c*, erect perpendicular lines to represent the angles of the building; and the points D and E will be the points to which the sides of the building will respectively appear to vanish. Make the line B equal to the height of the building, and from the top and bottom of it draw lines towards D and E, till they cut the lines *a* and *c*, which will finish the outline of the building.

It is usual to bisect the angle AOC, figure 5, and to make the plane of the picture, DE, at right angles to the line of bisection; but this method is not essential to the accuracy of the rule itself. The plane of the picture should, in all cases, be drawn at right angles with the line of direction in which it is determined to look at the object, whether that line happen to bisect the angle formed by the two outer visual rays, or otherwise.

This rule is perfectly correct, but it is only enable him to put the most difficult and complicated objects into perfect perspective. He is now in possession of an easy simple rule which will enable him to find the place upon his drawing for any point whatever, of course supposing that he has the situation of that point in the plan of the object, with its height from the ground. But as all objects are bounded by lines, and as all lines, whether straight or curved, may be considered to be made up of an infinite number of points, and being in possession of a rule by which the situation of any one of those points may be ascertained, it follows that the form under which the whole line would appear in the picture may be found. Hence it is that the rule in question is called a General Rule.

applicable to particular cases; and drawings made by this rule and by the General Rule, from the same data, will agree exactly with each other.

When the pupil has studied this rule sufficiently to make himself master of the main principle from which it was deduced, and has applied it in making a few drawings in perspective, he will find it to be remarkably simple in itself, and the application of it in practice to be perfectly convenient. From the number of lines in figure 3, the rule may at first sight be thought to be complicated and difficult; but though it was necessary to set forth all those lines in form, in order to explain the rule, yet, in practice, the pupil will find that he needs only draw the ground line, the horizon, and the line of the vertical section GH in ink; all the rest may be drawn, one at a time, in pencil, and then rubbed out, after they are transferred, in order to avoid confusion; and, in fact, it is scarcely necessary to draw any lines in this part of the work, because, when the ruler is laid down from the top or bottom of any of the perpendicular lines, as the line A for instance, the most accurate and expeditious method of marking where the line cuts the ink line GH, is to stick a pricker into the point where the ruler intersects it, and to let it remain there till the height is transferred by the compasses, and then there can be no mistake; and it has been shown before that the best way to mark the place of the observer's eye, is to stick a pricker into the point to guide the ruler, by which means the process is greatly facilitated and rendered more accurate.

But it must be admitted, that to put a complicated object into perspective, is a tedious operation, by whatever rules it may be performed. However, the learner will find that the difficulty will be greatly lessened by proceeding with the work in a systematical manner. For instance, instead of drawing lines from all the parts of the plan of the object to the observer's eye at first, only draw such lines as relate to the general outline of the object, and when these are done with, let them be rubbed out; then, supposing the object to be a building, proceed in like manner with the windows, the doors, and so on, till the whole is finished. By a careful attention to those methods of arranging the work, which practice will suggest, the process which appears to be so very tedious will be rendered comparatively easy.

As the pentagonal structure chosen as an example to illustrate the General Rule, consists entirely of straight lines, probably the young pupil may find it difficult to apply the rule to the drawing of curved lines, unless he have the assistance of a few examples to elucidate the subject, and for this purpose, figures 7 to 11 are given.

The pupil is advised not to proceed to the drawing of curves before he is thoroughly exercised in the application of the General Rule to objects consisting of right lines only, and he will then find no difficulty in drawing curves of any form, the system being exactly the same.

Suppose ABC, fig. 7, to be the plan of a gateway, of the front of which figure 8 is a geometrical elevation, and let it be required to put it into perspective, supposing the observer to stand at O, the plane of the picture to be at GG, and the height of the horizon as shown in figure 8.

As the pupil is presumed to know the mode of putting all the straight lines of this example into perspective, it will be only necessary to direct his attention to the method of drawing the arch.

Divide the width of the door-way, or diameter of the arch, into four or more parts, as shown by the letters *a*, *b*, *c*, figure 7; also divide the door-way, figure 8, in like manner, and erect the perpendiculars, *aa*, *bb*, *cc*. From the points *a*, *b*, *c*, figure 7, draw lines to the point O, and transfer the points *a*, *b*, *c*, in the line GG, to the ground line, figure 9, from which points erect the perpendiculars *aa*, *bb*, *cc*, for the same purpose as was explained in figure 2.

In the same manner as the apparent heights of the sides of the archway, up to the springing of the arch in figure 8, were found by the process as described in figure 3, find the apparent heights of the lines *aa*, *bb*, *cc*, and then transfer them to their corresponding lines in figure 9; and the three points *a*, *b*, *c*, in the arch, being determined, it is only necessary to draw a curve through these points to both extremities of the diameter of the arch, in order to give the true perspective appearance of that arch.

In this small example only three points in the arch are found, but it is evident that a hundred points could be ascertained in the same manner; and hence the appearance of any kind of curve may be found to the utmost degree of accuracy.

By reflecting on the method by which the perspective appearance of this one arch was found, it will be evident to the pupil, that all the various arches of the most difficult concamerated roof could be found by the same means.

Now if, instead of a gateway, figure 9 be supposed to be a steam-engine for instance, and that the semicircular arch were the half of one of its wheels, and the points *a*, *b*, *c*, in that arch to be three of the cogs or teeth of that wheel, it will be evident, upon an attentive consideration, that the place of every other tooth of that wheel could be found by the same rule; and a little more reflection will convince the pupil, that by the same means the situation of every pin and point in the whole machine could be ascertained to the utmost degree of geometrical precision.

As a second example of drawing curved lines, let it be required to put the serpentine line, or river, marked from *a* to *k*, figure 10, into perspective, as viewed by an observer at O, elevated to the height of the horizon line as shown in figure 11.

From any convenient points in the serpentine line, figure 10, draw lines to the observer's eye, as, for instance, the lines *h*O, *i*O, and *k*O; but as these lines cross other parts of the curve in the points *g*, *f*, *b*, *c*, and *d*, they will also serve as lines drawn from those points to the observer's eye, and thus, in this instance, five lines will answer for ten points in the curve.

Transfer the points 1, 2, 3, 4, and 5, in the line GG, figure 10, to the ground line in figure 11, erecting perpendiculars thereon, as before explained. Set off the distances O*a*, O*b*, O*c*, &c. figure 10, on the ground line of a figure similar to figure 3, and find how high they will respectively appear upon the plane of the picture, and transfer those heights to the proper vertical lines in figure 11; and when a curved line is carefully drawn through those points, the true apparent form of the serpentine line will be complete.

By the same process which found the places of the ten points in the serpentine line, the outlines of circles, polygons, and irregular figures, and also works of fortification, may be accurately found. The knowledge of this example would also be useful in laying out ornamental grounds and plantations, because by these means they may be arranged in such a manner as to produce a given effect, from any particular point of view.

The design of this small Treatise is merely to teach and sufficiently to illustrate one General Rule, leaving the pupil to apply it to his own purposes; but a large volume might be filled with the very difficult and curious problems which it is capable of solving.

It is proper to remark here, that when it is required to make a drawing of an object as it would appear to an observer at a very great height from the ground, it must not be supposed to be viewed at a greater angle than about 30 degrees with the horizon, otherwise we should have to find how the object would appear on an inclined plane, which application of the General Rule it is not the design of this Treatise to describe.

The pupil will perceive, that in the whole of the process he has been led through in this Treatise, he is supposed to be furnished with a correct plan of the object he is required to put into perspective, with the altitudes of all its parts. But if his design in turning his attention to the subject of perspective be merely to enable him to sketch landscapes and buildings from nature, as being a delightful and elegant accomplishment, he will naturally ask—must we then have a map of a country, with the heights of all the mountains, trees, and castles, figured upon it, before we can make a landscape drawing of that country? All this must be done, if it were required to make a view that should be mathematically correct, and absolutely perfect in all its parts; but though it is not necessary to be so perfectly correct in sketching from nature for the purpose of landscape painting, yet it is universally admitted to be impossible to sketch with any tolerable degree of truth unless the mind be acquainted with the theory of perspective, and has been sufficiently exercised in the practice of its principles to know the various forms under which objects appear, when viewed from certain situations.

In drawing a perspective view of an

architectural design, the draftsman has the plans, sections, and elevations of the proposed building before him, and he can work by rule as much as he pleases; but in sketching from nature, the artist must necessarily trust to his eye, assisted merely by a few vanishing points. But though we see merely a point or two on the artist's paper, yet if he sketch correctly, he is only enabled to do so, by the knowledge of perspective which he had previously laid up in his mind. The pupil is therefore recommended to make himself master of the fundamental principles of perspective, which have been submitted to his consideration in this Treatise; and to make very accurate drawings in detail of a variety of objects which he may have at hand, such as models of buildings, machinery, or even articles of furniture, and of serpentine lines, circles, cylinders, pyramids, &c. and then when his mind has become familiar with the perspective appearances of these objects, he will find that he is prepared to sketch towers, churches, mountains, rivers, &c. from nature with accuracy. Let not the pupil deceive himself, for, how bold and vivid soever his imagination may be, he will do well to recollect, that nature has her laws by which the appearances of all objects are governed, and that if he wish to represent those appearances correctly, he must submit to learn those laws, however tedious and mechanical the process may be.

DIRECTIONS FOR DRAWING FROM MODELS, PARTICULARLY ADAPTED FOR TEACHING PERSPECTIVE TO YOUNG PERSONS.

One of the best experiments to which a perspective drawing, made from given data, can be subjected, in order to try the truth of the rules by which it was drawn, will be to trace an outline of that drawing upon a pane of glass, and then to erect a frame-work, or model, answering to the same data; and if, when the glass is placed in its proper situation between the eye and the model, the drawing be found to answer line to line and angle to angle with the model itself, it must surely be granted that the rule by which it was made is nothing less than perfect.

The young pupil who wishes to acquire a clear and thorough knowledge of the principles and practice of perspective, is recommended to try the truth of the theory upon which the General Rule is founded, by bringing it to the test of an actual experiment, which may be easily done in the following simple manner.

Paste two sheets of cartridge paper on a drawing board, or table, about three feet six inches long, by about twenty inches wide. Construct upon the board the whole of figure 1, according to its dimensions when measured by the scale; and let these dimensions be considered as inches, and lay down the figure to the full size. Begin by drawing a line along the middle of the board lengthways, and mark it OS, taking care that the point O be close to the edge of the board. At the end of the board opposite to the place of observation, O, construct the irregular pentagon, ABCDE, which may be readily done by taking the necessary dimensions from the scale.

Procure about six yards of copper bell-wire. Cut off five pieces, each eleven inches long, and turn one end of each piece into a small eye; and then place one of these wires at each of the angles of the pentagon, into holes made for that purpose about half an inch deep, to represent the pillars of the building. Bend a piece of the wire into the exact form of the pentagon, as drawn on the board, and then pass it through the eyes of the upright wires, and adjust it so as to make it stand level, and at the given height from the board. Make a hole at the point F, in which place a wire, with an eye at the top, standing sixteen inches from the board. To the top of this wire hook five other wires, and fasten the ends of them to the tops of the wires which form the pillars. Adjust the whole, by seeing that the wires are all straight, and that they are level, or perpendicular, as the case may be; and we shall have an outline model of the pentagonal building according to the given data.

From the foot of each of the wires which represent the pillars, draw a line to the point O. At right angles to the line OS, and at a distance of say fourteen inches from the point O, draw a line, and mark it GG.

Procure a pane of glass about ten inches by nine, (which must be washed over on one side with strong gum arabic water) and holding the edge of it upon the line GG, mark off the points *b*, *c*, *d*, *f*, *a*, *e*, from which points erect perpendicular lines, and mark them as shown in figure 2.

On two sheets of cartridge paper joined together, so as to make a sheet sufficiently long, draw the ground line, figure 3, also the horizon line, and the vertical line GH, in ink, and proceed to finish the drawing on the glass, as in figure 2, according to the directions given before relative to figures 3 and 2. Let the outline of the building on the glass be drawn in strong lines with a pen and thick Indian ink.

With a piece of tin or pasteboard make a sight, and fix it so that the hole may be exactly over the point O, and at the height of five inches from the board.

Place the pane of glass upon the line GG on the table, so that the marks on the bottom edge of it may be over the corresponding marks in the line GG, and prop it up so that it may stand perpendicularly to the board.

Look through the hole in the sight, and, provided all the work has been accurately done, it will be beautiful to see the drawing on the glass answer line to line and angle to angle with the model*.

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* Having constructed a model of the above description, it will also serve to exemplify the intricate subject of projecting either sun or candle-light shadows.

If the model be placed in the light of the sun, whose rays may be considered as falling upon objects in parallel lines, the shadows cast upon the table from the vertical wires will be parallel to each other; but the direction and length of the shadows depend upon the situation and height of the sun above the horizon.

If it be placed in the light of a lamp, the shadows from the upright wires will form parts of

In order to make the matter as plain as possible, figure 4 is a perspective drawing of the model, the pane of glass,

radii, the centre of which would touch a plumb-line suspended from the lamp; and if a string were stretched from the flame to any one point of the shadow on the table, it would touch the corresponding point of the model.

As an example; let it be required to draw the perspective appearance of the shadow which the model would throw upon the table when placed in the light of a lamp.

From the point upon the table directly under the lamp, draw lines against the feet of the several pillars, or vertical wires. Upon a separate paper, draw a ground line, from one end of which raise a perpendicular equal to the height of the lamp above the table; and, from the foot of this line, set off upon the ground line all the several distances from the point under the lamp to the pillars, and upon these distances erect perpendiculars equal in height to the pillars. Draw lines from the point which marks the height of the lamp to the tops of these perpendiculars till they intersect the ground line; then transfer the several distances between the perpendiculars and the points of intersection to the proper shadow lines on the table. Having thus found the lengths of all the shadows from the upright wires, draw the lines necessary to com-

and the sight, placed on a board, showing the experiment complete as recommended to be tried; and, in fact, an attentive consideration of this one drawing will serve to exemplify the whole theory and practice of perspective.

It is particularly recommended that young persons should be directed by their tutors to make models of various

plete the shadow of the roof, and we shall have a complete plan of the shadow upon the table. Prove whether the plan be correct by lighting the lamp; and then find the perspective appearance of the plan of the shadow by the same process that found the perspective appearance of the plan of the model itself.

Sun-light shadows may be found in a similar manner, except that all the lines in the process which represent the rays must be drawn parallel to each other.

Though, in many cases, shadows may be drawn upon a perspective drawing, without the process of finding the outlines of them upon the ground plan, yet the above system will be found extremely useful, especially in learning the theory.

kinds of buildings, or other objects, with wire, or slips of wood, or pasteboard having doors and windows drawn on it, and then to make perspective drawings from these models in the manner just described.

After having made a perspective drawing of the model, very correctly according to rule, the pupil should then exercise himself in sketching that model by the eye only, from the same point of view as the other drawing was made. By comparing the two drawings together, he will see his errors; and perhaps no better system can be suggested for preparing the pupil to sketch from nature.

This system of learning from models has many important advantages. It will make their studies interesting; and by seeing step by step the reason of the rule they work from, they will acquire clear and accurate conceptions of the subject, and when their drawings are made, they will have the means of proving their accuracy. By thus making perspective drawings from models, they will not only learn perspective thoroughly, but they will at the same time be acquiring the power of thinking correctly upon geometrical subjects in general; and it is well known, that unless the mind, at some period, pass through a course of instruction of this nature, it must, of necessity, be incapable of comprehending many important branches of knowledge which are essential to a liberal education.

APPENDIX, No. 1.

METHOD OF CALCULATING THE APPARENT SIZE OF AN OBJECT, AS IT WOULD APPEAR ON A TRANSPARENT PLANE, PLACED BETWEEN THAT OBJECT AND THE EYE.

EVERY body knows that objects appear to diminish in size in proportion as we recede from them; but perhaps the ingenious pupil may like to have some information respecting the law by which this apparent diminution is governed.

He will find by experiments, that the

apparent size of an object decreases in proportion as the square of the distance from the eye increases.

Let O, figure 12, be the place of an observer's eye. Open your compasses to any convenient width, and, from the point O, mark off four or more equal distances, through which draw the parallel lines, marked 1, 2, 3, and 4, and make each line equal to one of those distances. Consider line No. 1 to be the edge of a pane of glass upon which it is required to draw the apparent sizes of the lines Nos. 2, 3, and 4, as they would be seen by an observer at O. Draw lines from O to each extremity of the lines Nos. 2, 3, and 4, to represent rays of light passing from them to the observer's eye. Divide line No. 2 into two equal parts, No. 3 into three equal parts, and No. 4 into four equal parts. It will be found that the distance between the rays of light, passing from the extremities of line No. 2 to the observer's eye, at the points where they enter the glass, marked 2, 2, is equal to one-half of line No. 2; that the distance 3, 3, is equal to one-third of line No. 3; and that the distance 4, 4, is equal to one-fourth of line No. 4.

Now suppose a piece of paper, cut exactly square, to be set up on the line No. 4, having its sides equal to the length of that line, and its surface divided into sixteen square and equal parts; and conceive another piece cut equal to one of these sixteen squares, and pasted on the middle of the glass, between the points 4, 4. To an observer at O, this small square would exactly cover the whole of the square on line No. 4; therefore the apparent size of the large square is only equal to one-sixteenth part of its whole surface; or, in other words, it has appeared to decrease in proportion to the square of its distance from the eye — its distance four being multiplied by four, making sixteen. Of course, similar remarks will apply to squares placed on the lines Nos. 2 and 3.

This subject may be more familiarly illustrated by the following experiment: Make two triangular prisms of cardboard, one four inches high, with each face an inch broad, and the other one twice as large. If the smaller prism be placed about eighteen inches from the edge of a table, and the other placed at the same distance beyond it, they will appear exactly alike to an eye viewing them from the edge of the table. The whole of figure 12 may be exemplified in the same manner.

The size which an object would appear

on a transparent plane placed between that object and the eye, may be found by the following rule :—

As the distance of the eye from an object is to its height, so is the distance of the eye from the transparent plane to the apparent size of the object upon that plane.

Example.—Suppose an observer to stand at the distance of 1000 feet from the monument of London, which is 200 feet high, it is required to find the exact height it would appear on a glass held up at the distance of 3 feet from the eye?

1000 : 200 :: 3 : 6-10ths of a foot, or 7¼ inches nearly, the apparent height required.

APPENDIX, No. II.

DESCRIPTION OF AN UNIVERSAL RULER, WITH THE MODE OF APPLYING IT TO PERSPECTIVE.

Invented by S. B. Howlett.

THE common rolling parallel ruler is made upon the principle of a rolling cylinder; but the Universal Ruler not only improves and extends all the advantages to be derived from that principle, but it is so contrived as to render the principle of a rolling cone also available for practical purposes. These two principles combined form so useful an instrument, and being admirably adapted for making perspective drawings, it is presumed that a description of the same appended to this treatise will not be unacceptable.

On the ends of the wire AB, figure 13, which measures 21⅙ inches long, and ⅕ or ¼ of an inch in diameter, a small wheel and a larger wheel are placed, each end of the wire having a shoulder and a fixing screw to receive them.

The part E is a flat ruler, 16½ inches long, and 2½ wide, having the upright pieces C and D fixed at the ends, and projecting a little beyond the edge of the ruler to keep it steady, with a slit in each of sufficient depth and width to receive the wire AB, and allow it to revolve freely. The bevelled edge of the ruler is formed into a scale of 16 inches long, divided into inches, thirds, and tenths, and figured right and left; and placed in the middle of the ruler, so as to leave a quarter of an inch at each end between zero and the upright pieces C and D, to allow room for the sliding arm *c*. At 1½ inch from the bevelled edge there is a wire, *ab*, runs the whole length of the ruler, about the eighth of an inch above it, and fixed in the ends C and D, upon which there is an index, or arm, *c*, made to slide, with a slit in it to hold a pencil, drawing pen, or steel point for engraving.

When the ruler is laid upon the paper, and the wire with the wheels on it, is placed either way in the slits C and D, if the fingers be pressed upon the wire over the part E, the instrument may be rolled up and down the paper at pleasure, which will cause the pencil at *c* to draw an arc, and every line drawn against the bevelled edge of the ruler, which is immediately under the outer edge of the wire, will tend to the centre of that arc, because the two wheels form, in effect, the frustum of a cone.

As it is evident that the size of the circle described by the passage of the instrument depends on the relative size of the wheels at A and at B, it is necessary that it should be furnished with several wheels, in sizes, to be fixed on the wire at B, according to the radius of the arc required to be drawn; and it must have three wires—two for drawing arcs, and one for drawing parallel lines.

When the largest wheel, according to the following table, is placed on the wire, and the ruler fixed close against the small wheel at A, by means of the tube and screw *d*, it will cause a pencil at zero, next to the small wheel, to draw an arc of

6 inches radius, and when placed at zero at the other end of the scale, to draw one of 22 inches radius.

It is evident that arcs of every possible radius between 6 inches and infinity may be drawn by this instrument, according to the number and size of the wheels with which it is furnished. For it, to describe arcs in regular succession, there must be as many wheels as there are lengths of the scale in the radius of the largest arc it is designed to draw. Thus an instrument of the dimensions now described, to draw arcs of any radius from 6 inches to 12 feet 6 inches, will require nine wheels, similar to that at B, and two, similar to that at A; and each wheel must be marked with a letter referring to a table, showing the arcs which it will cause the two zeros of the scale to describe, and of course an arc of any radius between the two zeros may be drawn by sliding the index on the scale to the dimension required.

The following table shows, in inches, the sizes of the several wheels, and the arcs they will respectively describe.

These wheels on one end of the wire.		And these wheels on the other end.		Will cause zeros to draw arcs of these radii.	
Marked.	Diameter.	Marked.	Diameter.	Zero next small wheel.	Zero next large wheel.
X	1.00	A	5.00	6	22
Z	2.00	B	3.98	22	38
		C	3.11	38	54
		D	2.79	54	70
		E	2.61	70	86
		F	3.50	86	102
		G	2.42	102	118
		H	2.36	118	134
		I	2.32	134	150
P	2.00	P	2.00	Parallel	lines.

The wheels X and Z may be permanently fixed on two of the wires; and the third wire is for the wheels PP, which, being equal in diameter, make the instrument a parallel ruler of the very best construction.

But each wheel is capable of drawing a larger arc than that which is shown in the table, by merely clamping the ruler against the large wheel instead of the smaller one.

The table is calculated upon the principle of allowing ¾ of an inch from zero to centre of small wheel at A (fig. 13), and 21⅙ inches from outside of wheel at A to outside of wheel at B, and reckoning wheels ⅓ of an inch thick.

The proper diameters for the wheels of an instrument of this description may be found by the following proportion:

As the radius of the arc intended to be

drawn by the first zero, less ¾ of an inch, is to the diameter of the small wheel, so is the distance from the centre of that arc to the outside of the larger wheel, to the diameter of that wheel.

The wheels should be made of wood, and may be of any thickness, with their edges sloped, so as to be in a line with the edge of the wheel at the opposite end of the wire; and the small wheels marked X and Z (*vide* Table) should be turned in the form of zones. When the wheels are made so thin as ⅓ of an inch, they should be turned out of two thicknesses of stuff, glued together the contrary way of the grain, to prevent them from warping.

The wheels may be easily adjusted in the following manner: On a long table draw an angle similar to figure 14, and the wider it opens the better. As the first zero, with wheel A, (*vide* Table), is intended to draw an arc of 6 inches radius, set off 6 inches from the point O on both lines, and divide the rest of each line into as many equal parts as there are wheels to adjust, making each part equal to the distance between the two zeros of the ruler, namely, 16 inches, and figure each division on one line according to its distance from the point O, and mark the divisions on the other line with the letters of the wheels intended to draw arcs of those several radii. To adjust wheel D, for example, which is designed to draw arcs from 54 to 70, place the ruler against the lower line with one zero against D and the other against C, and rule it forward to the upper line; and if the zeros do not agree with the line and the figures, the wheel D must be reduced, till, by trials, the ruler is made to agree with both lines. If the wheel be too small, it is of no use; but if it be too large, it may be reduced by rubbing the pair of wheels on a table with the edge of the wheel required to be adjusted on a sheet of glass paper, holding the hand firmly on the wire, and at the same time turning it round.

An instrument of the above description can draw straight lines of any length, raise perpendiculars, draw parallel lines, sweep arcs of any given radius, and draw any number of radii, or lines tending to one common centre, however distant it may be; and it has the peculiar convenience of being able to perform all its operations within the limits of the paper or copper upon which the drawing is to be made.

But for drawing perspective only, this ruler may be made in so simple a manner, that any person of moderate ingenuity could manufacture one for himself. For this purpose the wire *a b*, figure 13, and the arm *c*, and also the scale, may be dispensed with; and two common wires merely, with about four wheels, are sufficient, and the upright pieces C and D may be formed of wood.

Having given a general description of the Universal Ruler, and hinted at a few of its uses, we will proceed to describe the method of applying it to the making of perspective drawings.

By whatever rule the *outline* of an object has been put into perspective, the Universal Ruler will be found of admirable use to draw in the detail. In order to explain the manner of adjusting and using the ruler, let it be required to complete the drawing of a building, the outline of which is similar to figure 6. If the drawing be large, or the lines vanish very slowly, put a small wheel on the wire; but if the drawing be small, or the lines vanish abruptly, a larger wheel must be used. To draw all the lines in the building which tend towards the same point on the right hand side of the paper, put the wire in the ruler with the small wheel on the right hand side. Place the bevelled edge of the ruler against the horizon, and roll it up to the top of the right face of the building, and if the ruler slope too much to agree with the line, roll it down again to the horizon, and move it altogether a little to the right (which will have the effect of making the vanishing point more remote) and *vice versa* if the ruler be found to slope too slowly. By these means, or by putting a different wheel on the wire, the ruler may be readily adjusted, so as to agree exactly with the horizon, and the top and bottom lines of the building. When thus adjusted, care must be taken to mark where the small wheel crosses the horizon; because in all cases the ruler should be set against the horizon, as being a proper line to start from, with the wheel against the mark, in order that the wheels may always keep the same path on the paper.

To draw all the lines which tend towards the same point on the left hand side of the building, place the same wire in the ruler, only with the small wheel on the left hand, and adjust the instrument as before. It will frequently happen that the same wire and wheels will serve for both sides of the building, but if it do not, then one of the spare wires must be employed with another wheel; and, when adjusted, a mark must be made where the small wheel crossed the horizon, as before explained.

It is scarcely necessary to mention, that in adjusting the instrument care must be taken that the whole of the object be included between the wheels.

It may not be considered out of place to remark, that the ruler in question is particularly adapted for engraving objects which have sloping lines tending to a distant centre. When the outline of the original is transferred to the plate, it is still necessary to find the several centres, however distant, to guide the common ruler; but the Universal Ruler may be adjusted to the outline with far less trouble, and the inconveniency of using a long ruler and distant points is avoided.

APPENDIX, No. III.

METHOD OF MAKING PERSPECTIVE DRAWINGS BY MEANS OF THE UNIVERSAL RULER AND CALCULATIONS.

LET it be required to put the building ABC, figure 5, into perspective, by means of the ruler and calculations, supposing it to be viewed by an observer standing at the distance of a 102 from the point B, and looking in the direction of the line BS.

At right angles to the line BS, draw a portion of the line DE to represent the plane of the picture. Having fixed the proper wheels on the wire for drawing an arc of 102, according to the table given in Appendix, No. 2, place them in the ruler with the small wheel clamped close against the right hand end of it; and set the index against 102 of the scale, which in this case will be at zero. Place the bevelled edge of the ruler to the line BS, with the pencil upon the point B, and roll the ruler so as to draw an arc, as shown in figure 5, the centre of which will be the place of the observer's eye, at the distance of 102*.

With the ruler in the same position,

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* When the ruler is used in this part of the process, such a distance should be chosen for the place of the observer as will not render it necessary to slide the index into the middle of the ruler. In the example, 102 is chosen, because the wheel marked 102 to 118 will leave the whole length of the ruler unoccupied, and ready to draw lines from the several parts of the plan to the line of the picture.

draw a line from the arc to the point A, crossing the plane of the picture at the point *a*; and minute down, upon the lines in the drawing, the distances, as shown by the scale, from the arc to *a* (6), and from the arc to A (48). Roll the ruler down to the point C, and draw a line from thence to the arc; which line, as well as the line A *a*, would, if produced, cross the place of the observer's eye. Minute down, as before, the distances from the arc to *c* (8), and from the arc to C (103.)

Transfer the points *a*, B, *c*, to the horizon, figure 6, and through them draw the vertical lines *a*, B, *c*; and make B equal to the height of the building, say 50, and suppose the horizon to be 15 from the ground.

In order to apply the ruler to complete

the building, it is necessary to find the top lines of the two faces of it, by which to adjust the ruler so as to draw the bottom lines, together with the windows, doors, &c. to do which we must calculate the heights of the ends *a* and *c* of the building as they would appear above the horizon, which may be done as follows, according to the rule given in Appendix, No. 1, and the dimensions as minuted on the several lines in the drawing.

From height of building, 50, deduct height of horizon, 15, leaves 35 for height of part above it. Then say, as the distance O A, figure 5, (102 + 48), is to the height of building above the horizon (35) so is the distance O *a* (102 + 6) to the apparent height of building at A as it would be seen on a glass at the point *a* in the line D E. This proportion, when worked out, will give 25 and 2-tenths for the apparent height of 35, as was required.

Set off 25.2 from the scale, on the vertical line *a*, above the horizon figure 6, and a line drawn from the top of line B to top of line *a* will be the top of the right face of the building. Adjust the ruler to this line and to the horizon, as shown in Appendix, No. 2, and roll it down to the bottom of line B, and draw the ground line of the right face of the building.

Proceed in exactly the same way to calculate, and to adjust the ruler for the left side of the building, and the outline will be completed.

The vertical lines of the doors and windows must be found in all cases in the same way as the lines *a*, B, and *c*, were found, namely, by drawing them from the plan, figure 5, to the plane of the picture, and then transferring them to figure 6. The heights of the doors and windows are to be set off on the line B, and drawn on either side by the ruler; and of course the top of the roof or the chimneys may be found by calculation, and be drawn by the ruler in the same manner.

It will be perceived that no use has been made, in this process, of the lines O D and O E, figure 5, nor of the points D and E, figure 6, which, it will be recollected, the common method rendered necessary; but as it often happens that these lines are of a most inconvenient length, with the vanishing points extremely remote, it is presumed that the system now explained will be found to be of utility, because, by such means, the whole of a drawing may be constructed without extending a line or placing a point beyond the margin of the paper.

The knowledge of the law which governs the apparent diminution of objects, with the mode of employing it to practical purposes, would, it is submitted, be of essential service in assisting an historical painter to draw the architecture of his picture, and to determine the proper heights of his figures according to the distances at which he intends them to appear. For if some of our greatest painters had recollected, that a figure which is supposed to be as far back in the picture as the observer is required to stand from the canvas, should only be drawn one-half the size of a figure in the fore-ground, and so on in proportion, we should not have to regret that many works of genius contain a number of disproportions, which the mind instinctively adopts as data by which to judge of distance, and hence the effect of the picture is destroyed.

THE END.

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